LANDSCAPE CONDITIONS AND TRENDS IN AND AROUND Rocky Mountain National Park: Initial Summary Results

Produced by the project:

Ecological Condition of US National Parks: Enhancing Decision Support Through Monitoring, Analysis, and Forecasting

Also called:

Park Analysis of Landscapes and Monitoring Support (PALMS)

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Abstract

The goal of this project is to integrate the routine acquisition and analysis of NASA Earth System Science products and other data sources into the NPS I&M decision support systems and use these NASA products to evaluate and forecast ecological condition of US National Parks. The project focuses on four sets of national parks to develop and demonstrate the approach: The Delaware Water Gap and Upper Delaware National Recreation Areas, Sequoia Kings Canyon and Yosemite National Parks, Yellowstone and Grand Teton National Parks, and Rocky Mountain National Park. This document reports initial findings on landscape trends and conditions in and around Rocky Mountain National Park. After a short introduction, the report highlights initial results for each of the indicators evaluated. The report concludes with a synthesis and interpretation of the trends to identify the primary past and potential future changes to landscape condition that are most relevant to management.

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Introduction

The need for monitoring and decision support for US National Parks is heightened by the rapid change that is occurring in and around parks. To address this need, National Park Service (NPS) has developed the Inventory and Monitoring (I&M) Program to provide a framework for collecting and archiving data pertaining to park vital signs including physical, chemical, and biological elements of ecosystem processes within parks. The NPS I&M is increasingly interested in the use of remotely sensed data and ecosystem models to simulate and forecast ecosystem conditions. In this regard**,** NASA data and products can substantially enhance the success of the NPS I&M effort.

The goal of this project is to integrate the routine acquisition and analysis of NASA Earth System Science products and other data sources into the NPS I&M decision support systems and use these NASA products to evaluate and forecast ecological condition of US National Parks, thereby enhancing natural resource management within and surrounding national parks. Specific objectives of this project are:

1. (a) Identify NASA and other products useful as indicators for NPS I&M monitoring and (b) delineate the boundaries of the surrounding park-centered ecosystems (PCE) appropriate for monitoring.
2. Add value to these data sets for understanding change through analysis and forecasting.
3. Deliver these products and a means to integrate them into the NPS I&M decision support framework.

The project focuses on four sets of national parks to develop and demonstrate the approach: Sequoia Kings Canyon and Yosemite National Parks, Yellowstone and Grand Teton National Parks, Rocky Mountain National Park, and Delaware Water Gap / Upper Delaware National Recreation Areas.

Now in the third and final year of the project, we are reviewing, interpreting, and finalizing study results with NPS collaborators through a series of three conference calls. The first reviewed the initial results with core NPS I&M collaborators, the second will synthesize interpret a fuller set of results to identify key trends and management challenges, the third will present final results to the fuller NPS staff associated with each park. More information on the project can be found at: http://science.nature.nps.gov/im/monitor/lulc/palms/index.cfm.

The goal of this document is to report the landscape trends and conditions in and around Rocky Mountain National Park The indicators being developed by the project and their current status are listed in Table 1. We first present patterns of change in key indicators from past to present and potential future change. We then interpret and synthesize these trends to help inform NPS decision making and management.

Table 1. Indicators developed for the PALMs project (*indicators for Rocky Mountain National Park).

Level	Category	Indicator	Spatial coverage & resolution	Temporal period & increment	SOP[1] and Reference	Status
Landscape dynamics	Monitoring area	*Protected area centered ecosystem boundaries	PACES; 30 m	2010	Piekielek et al. 2010 Hansen et al. In review	Completed
	Primary Production	*TOPS Gross & Net Primary Productivity (GPP/NPP)	US48; 1 km	2000-2009; daily & monthly	TOPS SOP Nemani et al. 2008	Completed
	Disturbance Events	*Rapid change in Vegetation index	US48; 1 km	2000-2009; monthly	TOPS SOP Nemani et al. 2008	Completed
	Land Cover	Impervious Cover Change	Chesapeake Bay Watershed; 30 m	1984-2005; each year?	PALMS SOP Jantz et al. 2009	Completed
		Future Scenarios of Impervious Cover	Chesapeake Bay Watershed; 1 km	2010-2030; decadal	Jantz et al. 2007 Jantz et al. 2010	Completed
		*Population Density (decadal)	US48; 1 km	1900-2007; decadal	Davis et al. in prep	Completed
		*Agricultural Area (decadal)	US48; 1 km	1900-2007; decadal	Davis et al. in prep	Completed
		*Rural Housing Density (decadal)	US48; 1 km	1860-2007, 2000-2030; decadal	Piekielek et al. in prep. Hernandez et al. 2007	Completed through 1999, being updated to 2008

	Biological Integrity	*Pattern of natural landscapes	US48; 270 m	1990-2030; 1992, 2001, 2030	Theobald 2009 Theobald et al 2010	Completed
		*Landscape connectivity	CBW; 30 m, 1 km US48; 270 m	circa 2000 circa 2000	Goetz et al,. 2009 Jantz et al. 2008 Theobald in prep.	Completed
		*Ecosystem type composition	PACE; 30 m	Presettlement; circa 2000	Piekielek et al. 2010	Completed
Air and Climate	Weather and Climate	*Phenology (NDVI, annual anomaly)	US48; 1 km	2000-2010; 8 & 16 day	TOPS SOP Nemani et al. 2008	Completed
		*Climate gridded daily	US48; 1 km	2000-2010; daily	TOPS SOP	Completed
Water	Hydrology	Surface Water Dynamics	CWB; HUC 10???	2005, 2030	Goetz et al. in prep. Melton et al. SOP	Completed
	Water Quality	Aquatic Macroinvertebrates (Biological IBI, sensitive taxa)	CWB; HUC 10???	2005, 2030	Goetz et al. 2008; Goetz et al. submitted; SOP	Completed

PALMS Indicators for ROMO

Delineating Protected Area Centered Ecosystems (PACE)

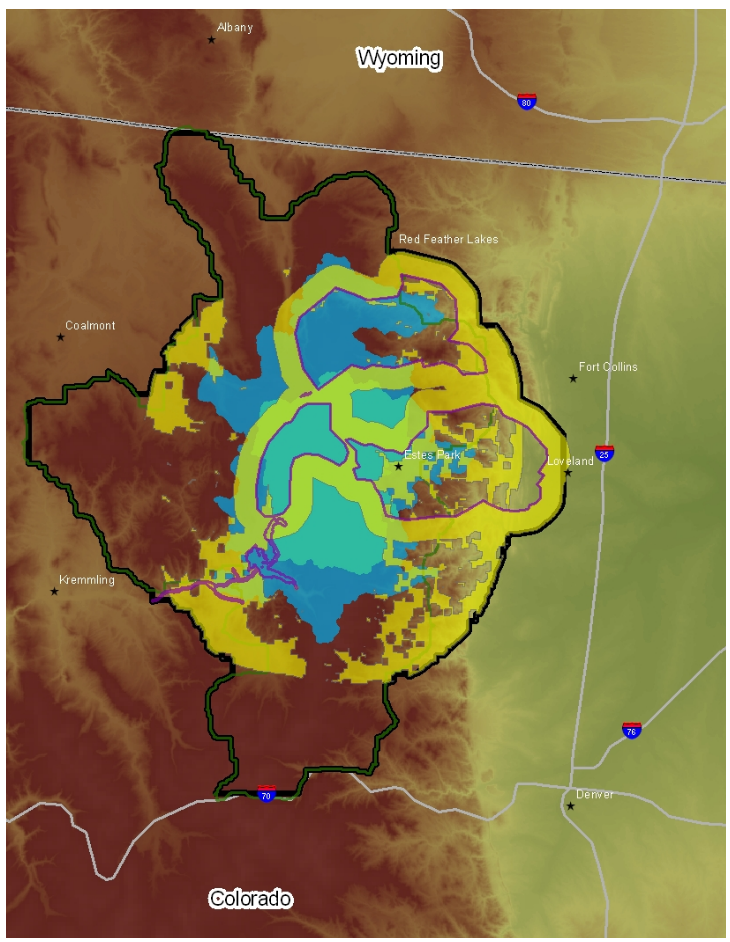
What: Area surrounding park with strong ecological connections to the park.

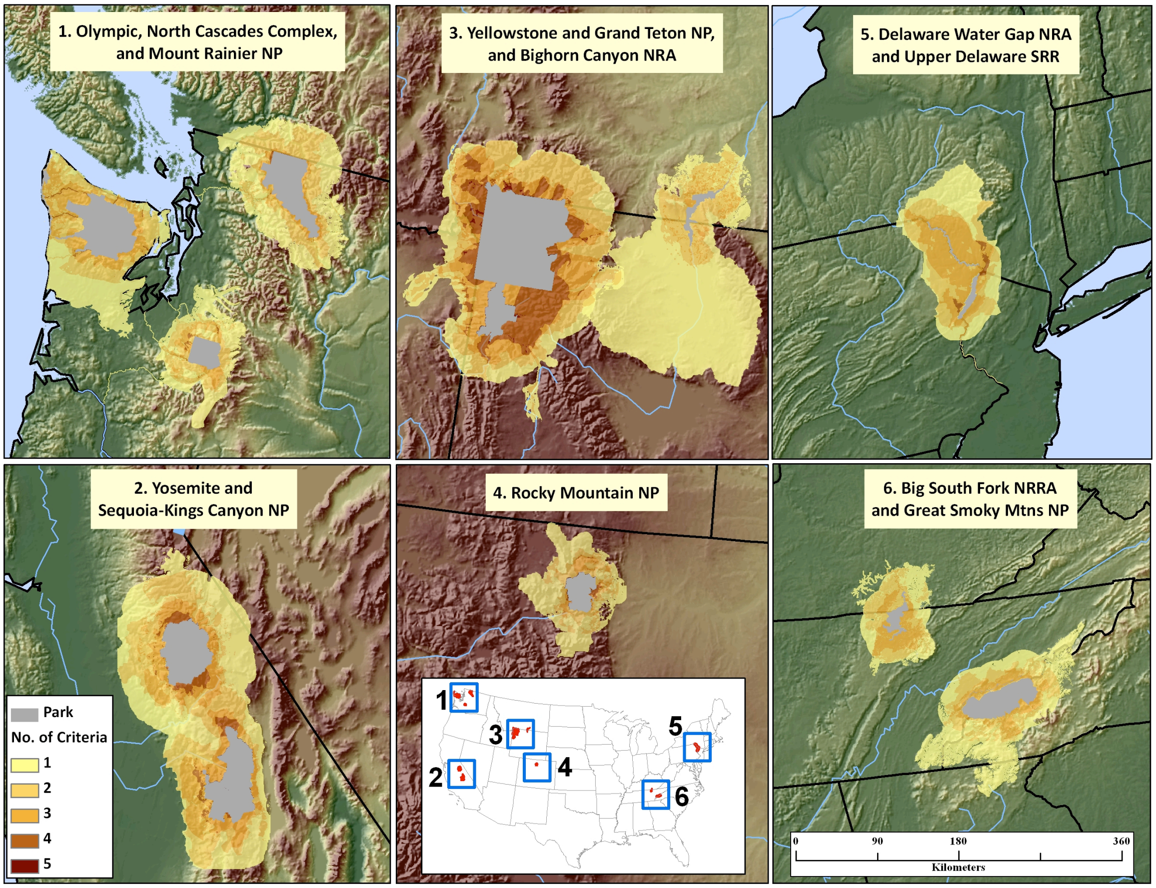
Why: This area may be important for monitoring, research, and cooperative management to maintain park

Summary: The ROMO pace outside the park was 8.8 times larger than the park area. The contiguous habitat layer covered the largest unique portion of the PACE, followed by the human edge effects layer. Some 34.5% of the PACE was covered by two or more criteria. Only 24% of the PACE outside of the park is private land, a smaller amount than for many other PACEs.

Metric	Total	Criterion				
		Contiguous habitat	Water-shed	Disturbance	Crucial Habitats	Human Edge Effects
Area outside park (km^2	9450	6768	1690	---	1398	1986
% of PACE uniquely covered		42.75	0.0	---	0.25	10.25

Solid blue = watershed, Purple line = crucial hab., Green line = contiguous hab., Solid yellow = edge effects, Black line = draft PCE boundary





Maps of protected-area centered ecosystems for Rocky Mountain and 12 US National Park units. Gradations in color in the PACES outside of the parks indicate the number of overlapping classification criteria. Places with many overlapping criterion may be considered more important for monitoring and management.

Ecosystem Productivity: Gross Primary Production

What: Estimates ecosystem productivity in terms of Gross Primary Production (GPP) and measures patterns and trends in GPP.

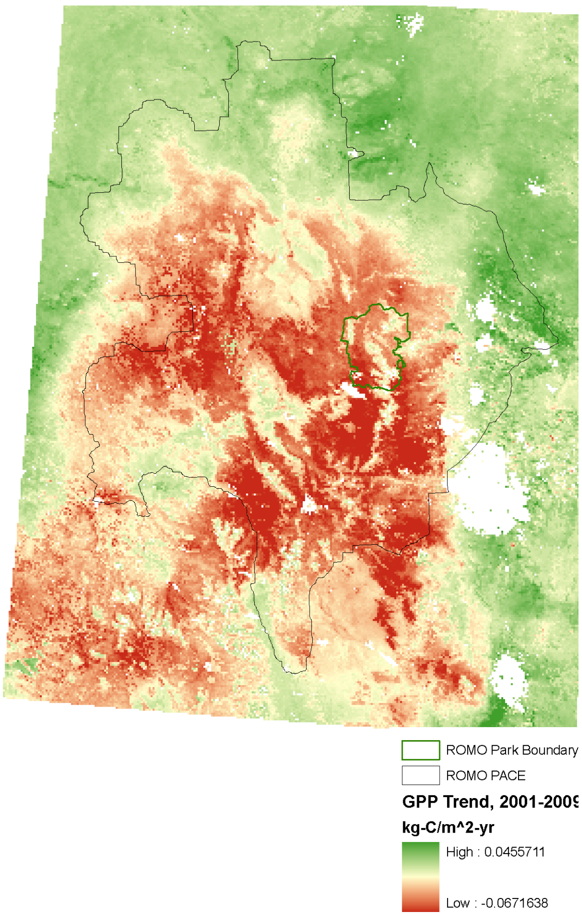
Why: GPP provides an indicator of ecosystem condition that integrates interactions between climate, vegetation, soils and other aspects of the physical environment. Sustained trends in seasonal or annual GPP may provide a leading indicator of climate change impacts.

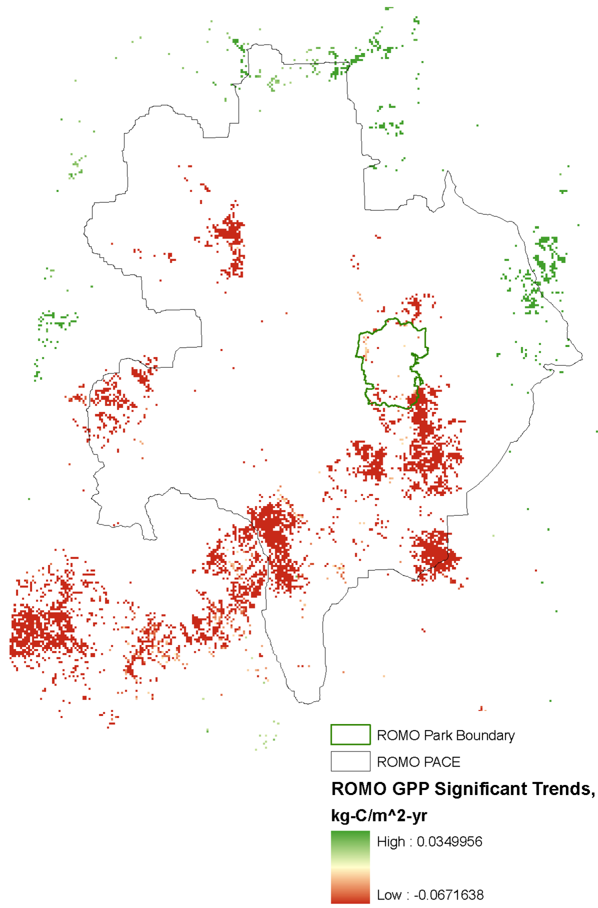
Stressors: Climate change, land use change, drought, wildfire, insect infestations

Summary: Summary measures for this indicator include maps of significant trends in GPP, and graphs and tables of cumulative GPP summarized by season and land cover type. This indicator relies on the use of MODIS data, and the TOPS implementation of the Biome-BGC model. Production of the dataset will continue under the NASA Earth Exchange (NEX) project for the foreseeable future. A draft 'dashboard' summarizing patterns from this indicator is posted at http://ecocast.arc.nasa.gov/dgw/dboard/ROMO

Annual GPP for the ROMO PACE has varied significantly for the period from 2000-2010, ranging from a high of 0.18 kg/m^2-yr in 2004 to a low of 0.1 kg/m^2-yr in 2009. There is an apparent negative trend in annual GPP for the PACE, possibly driven by the continuing expansion of the Mountain Pine Beetle (MPB) throughout the region, though 2008 and 2009 also had higher than average snow cover on April 1, which may have shortened the growing season and also contributed to reduced annual GPP in these years. Due to the interannual variability observed in GPP, a longer data record will be required to clearly detect significant trends for the park and PACE overall. However, statistically significant negative trends are reported for many areas within the PACE, likely associated with the recent expansion of MPB in these areas.

Figure: Maps of trends calculated from modeled annual cumulative GPP for the ROMO PACE. The overall trends for the region for 2001-2009 (left) are shown, and even with the short data record, the trends for a large area in the south of the PACE are statistically significant ($p < 0.05$) (right).





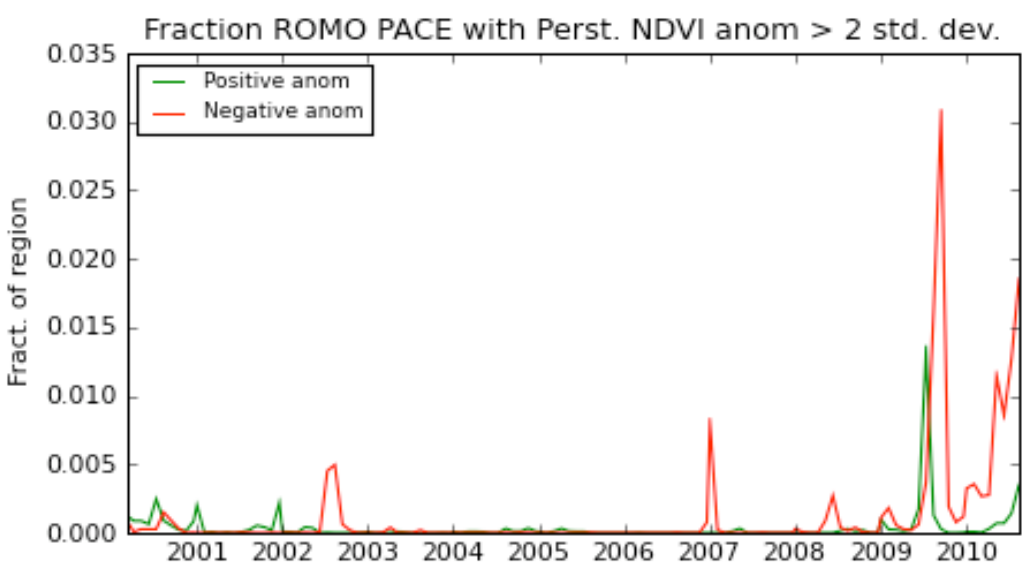
Landscape Dynamics / Disturbance Events: Vegetation Index Anomalies

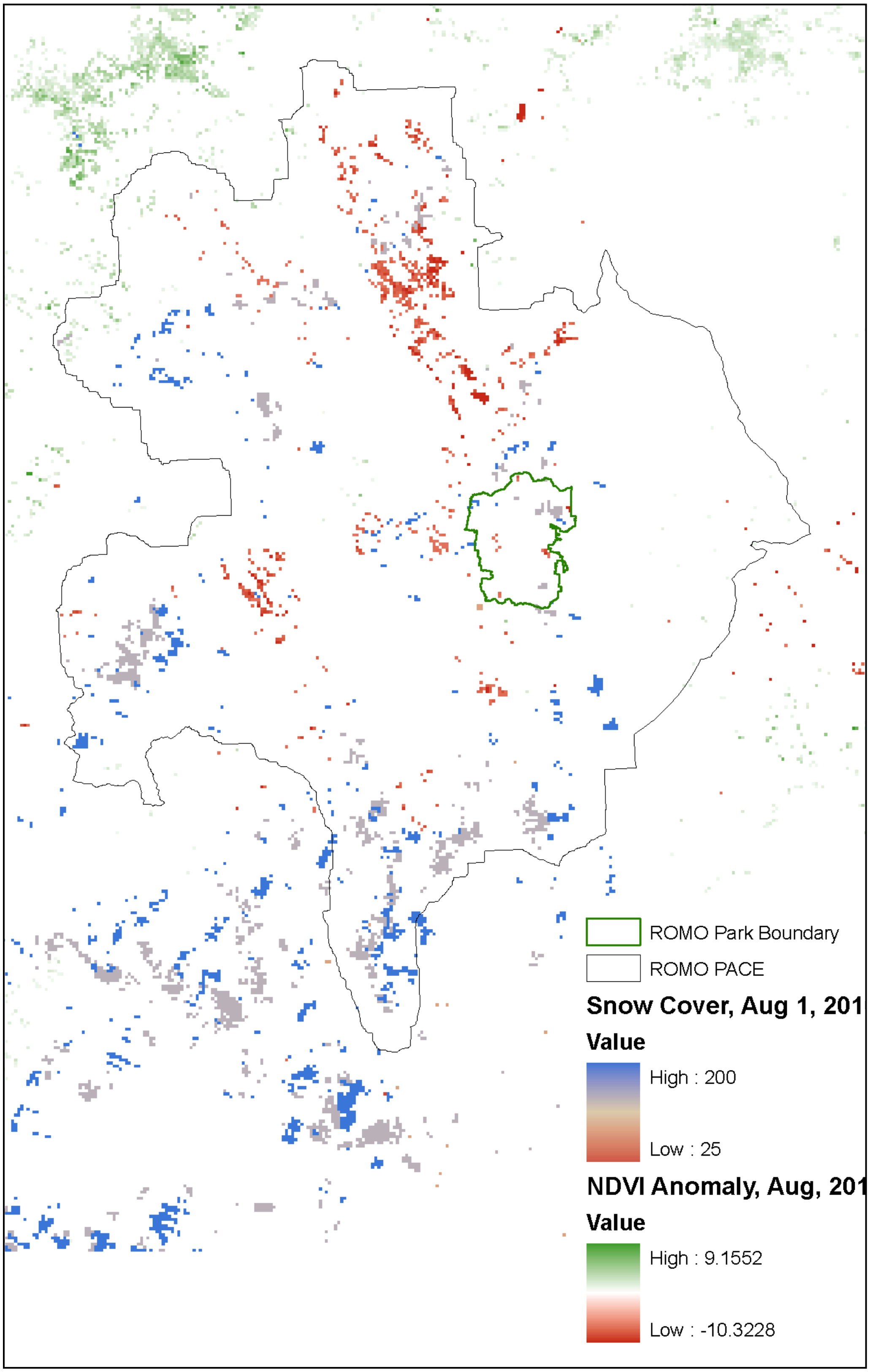
What: Summarizes indicators of change in vegetation conditions derived from MODIS Normalized Difference Vegetation Index data to detect spatial and temporal patterns in change.

Why: The MODIS NDVI product provides an indicator of vegetation condition calculated from daily MODIS observations over the ROMO PACE. Tracking changes in NDVI relative to average conditions provides an indicator of temporal and spatial patterns in changes in vegetation condition. Sustained shifts from historical normals may provide an indicator of important changes in park landscape conditions. This indicator is intended to complement Landsat-based indicators of landscape dynamics, which capture higher spatial resolution changes at an annual timestep.

Stressors: Land use change, drought, wildfire, insect infestations

Summary: Standardized anomalies used to identify short-term and persistent changes in landscape conditions indicate relatively few normalized in NDVI for the period from 2001-2009, with generally less than 3% of the park experiencing an anomaly that departs from historical normals by more than 2.0 standard deviations (Figure a). A recent anomaly map from August, 2010, shows both significant positive and negative anomalies within the PACE park boundaries and surrounding PACE (b). Significant anomalies may be tracked over time if proximate causes are not already known (e.g., fire, Mtn Pine Beetle, land use change, or late snowfall).




ROMO Park Boundary
ROMO PACE
Snow Cover, Aug 1, 201
Value
High : 200
Low : 25
NDVI Anomaly, Aug, 201
Value
High : 9.1552
Low : -10.3228

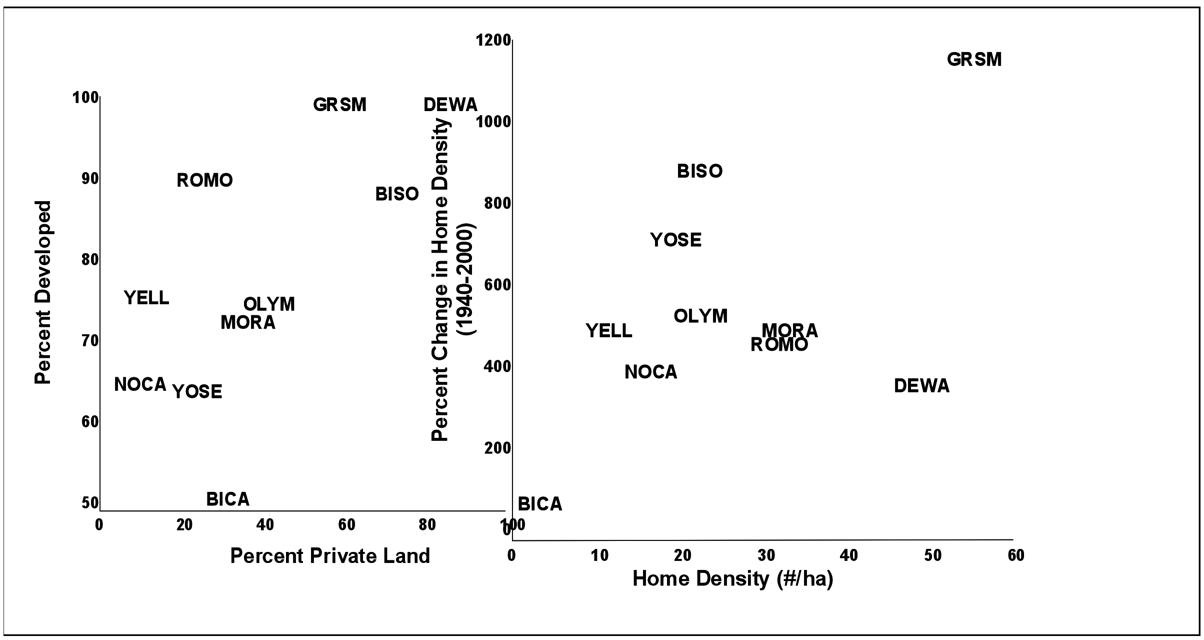
Landscape Dynamics: Land use within protected-area centered ecosystems (PACEs)

What: Metrics of land allocation and change in PACES outside of parks.

Why: These data provided indication of the challenges in maintaining park condition given the characteristics

Summary: Only 24% of the PACE outside of the park is private land, a smaller amount than for many other PACEs. Nearly 90% of those private lands are in agriculture, roads, homes or other land uses termed "developed". Home density in these private lands and growth in home density since 1940 are medial relative to the PACES examined thus far.

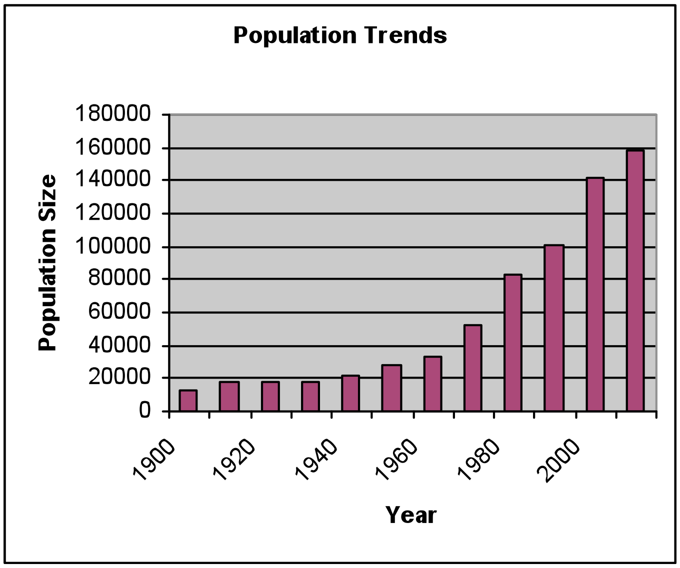
Percent of land that is private	Percent of private land developed in 2000	Home density on private lands in 2000 (#/km^2)	Change in home density on private lands during 1940-2000 (%)
24.0	89.3	0.323	455.2

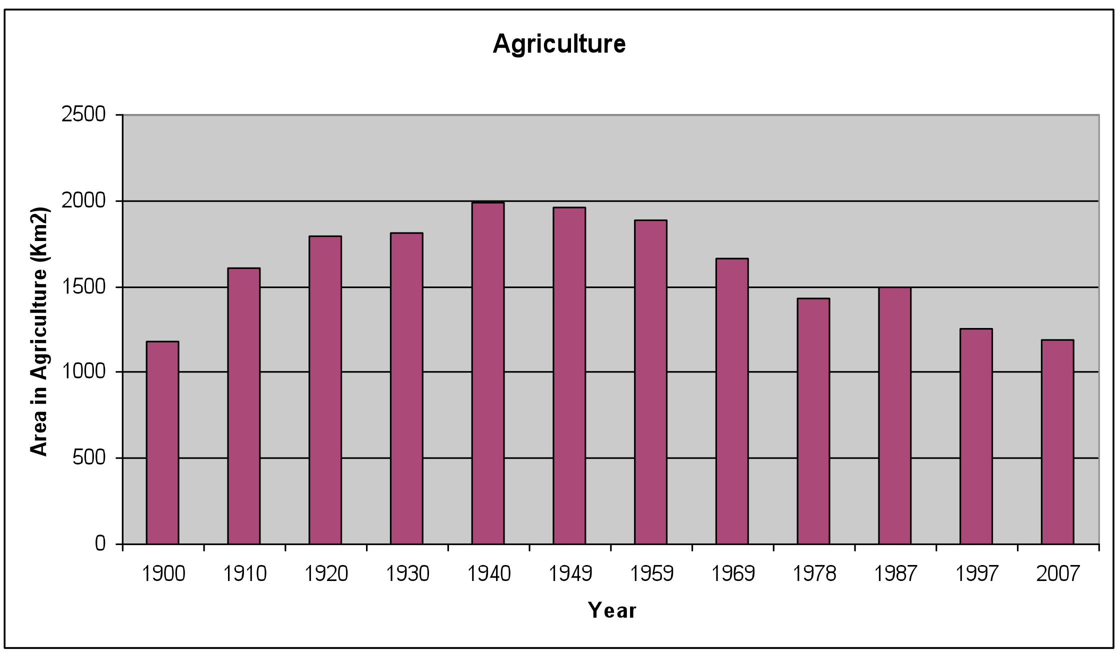


Location of the protected area centered ecosystems along gradients in land ownership and land development (home densities of >0.031 units/ha, roads, or agriculture lands) (left) and home density (units/ha) and percent change in home density from 1940 to 2000 (right).

Note: Developed lands included buffers of 1000 m adjacent agriculture or home densities>0.031 units/ha and 500 m of primary roads railroads and 100 m of secondary roads.

ROMO PACE: 1900 - 2007





Population distributed was distributed within PACE based on housing density. Ag data are for counties that cover >=10% of PACE or >=40% of the county is covered by the PACE.